

Localized Corrosion Phenomena in Powder-Processed Icosahedral-Phase-Strengthened Aluminum Alloys

S. Rommel^{1*}, H.R. Leonard¹, T.J. Watson², T. Policandriotes³, and M. Aindow¹

¹ Department of Materials Science and Engineering, Institute of Materials Science, University of Connecticut, Storrs, CT 06269, USA.

² Pratt & Whitney, Materials & Process Engineering, East Hartford, CT 06108, USA.

³ Collins Aerospace, Windsor Locks, CT 06096, USA.

* Corresponding author: Sarshad.rommel@uconn.edu

Recently, we have developed an icosahedral quasicrystal (I-phase) reinforced Al-Cr-Mn-Co-Zr alloy through gas atomization [1-3]. The powders have a nanocomposite FCC Al matrix / I-phase dispersoid microstructure, with Cr, Mn and Co preferentially segregating to the I-phase. The grain boundaries contain two types of precipitates – Co-rich and Mn/Cr-rich. This microstructure is retained during powder consolidation to form bulk material. The consolidated alloy showed promising physical and mechanical properties [1] and remarkable pitting corrosion resistance, outperforming conventional alloys in ASTM salt fog testing [2]. As such, investigations of the pitting behavior and the preferential sites for pit nucleation in the consolidated alloy are of interest.

TEM (Transmission Electron Microscopy) analysis of FIB (Focused Ion Beam) lift-outs from the surface of bulk material corroded in saline solution, revealed that the initiation points for corrosive attack were dependent on the surface morphology. However, this analysis was limited by the size and site-specific nature of the FIB technique; this would require multiple lift-outs to investigate all of the morphological features in the alloy microstructure. As an alternate, *ex-situ* corrosion experiments were performed on electron transparent TEM foils prepared by electropolishing. The same regions of the foils were compared through TEM and EDXS (Energy Dispersive X-Ray Spectroscopy) analysis before and after immersion in 3.5 wt% NaCl solution for 16 hours. This comparison was necessary to avoid the interpretation of possible electropolishing artifacts as corrosion damage. The regions of interest in the foils were tracked in reference to the central perforation. As a result, immersion times for the foils were limited to 20 hours, above which the perforation morphology was altered drastically due to oxide build up and corrosion damage.

Localized corrosion was found to occur primarily around the I-phase dispersoids and along the grain boundaries, in the form of local galvanic cells. The I-phase dispersoids and the Mn/Cr-rich grain boundary precipitates acted as cathodic sites, promoting dissolution of the surrounding matrix, while the Co-rich precipitates showed evidence of dissolution, suggesting anodic behavior. Matrix dissolution was more severe around the larger I-phase dispersoids, as compared to the relatively smaller grain boundary precipitates.

References:

- [1] TJ Watson et al., *Scripta Mater* **123** (2016), p. 51-54.
- [2] TJ Watson et al., *Corros Sci* **121** (2017), p. 133-138.
- [3] TJ Watson et al., *Surf Coat Tech* **324** (2017), p. 57-63.

[4] The microscopy studies were performed in the UConn/Thermo Fisher Scientific Center for Advanced Microscopy and Materials Analysis (CAMMA).

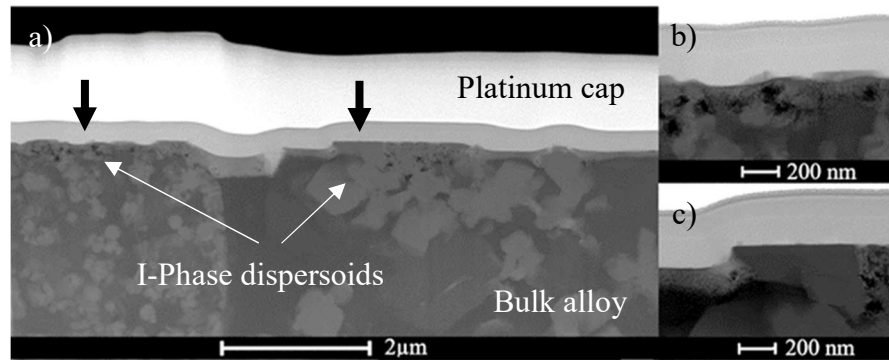


Figure 1. a) HAADF-STEM image of a FIB lift-out showing cross-section of the corroded surface for the consolidated alloy after 16 h immersion in 3.5 wt% NaCl solution; b) & c) magnified regions marked by arrows in a), showing corrosion attack on the Al matrix around the I-phase.

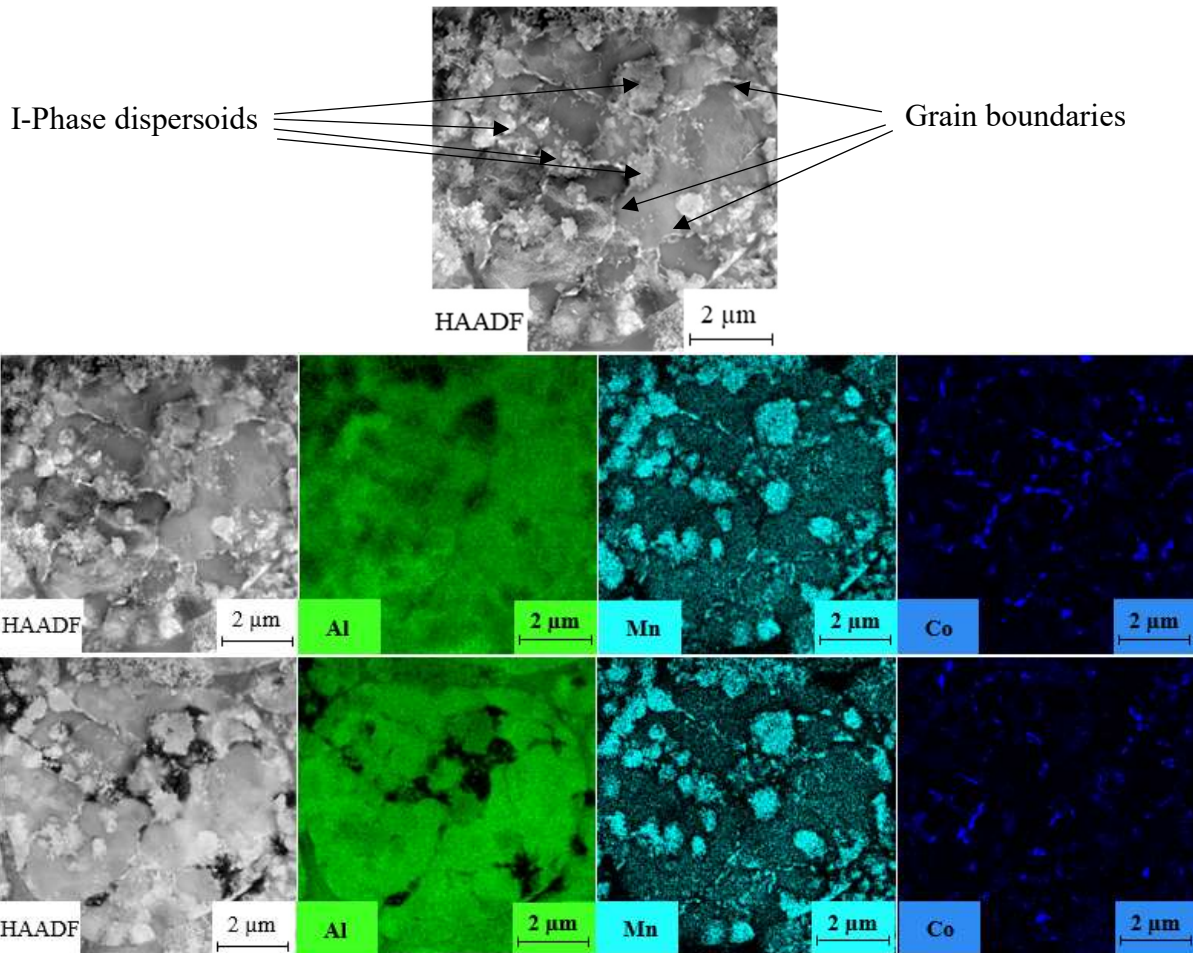


Figure 2. STEM data from an electropolished TEM foil of the consolidated alloy before (top row) and after (bottom row) immersion in 3.5 wt% NaCl solution for 16 h. These data show Al matrix dissolution around the I-phase dispersoids and along grain boundaries. Co-rich grain boundary precipitates also show evidence of dissolution.